

MODELING AND SIMULATION

PEO Land Systems Marine Corps has a continuing requirement for the development of an integrated suite of non-proprietary multi-variable Modeling and Simulation (M&S) tools. These tools must leverage existing ground vehicle simulation tools and enable M&S-based acquisition and lifecycle management of tactical ground vehicles to include cost data. The ultimate value of a fully integrated M&S toolset will be the ability to maximize the effectiveness of limited resources through simulation-based acquisition, while bringing optimized, focused capabilities to the Warfighter.

Computer-based simulation of the functions of tactical vehicle systems must be expanded to shorten development time and reduce program risk/cost. Currently, not enough components are accurately simulated and few are simulated together as a system (co-simulation). A fully integrated simulation-based acquisition approach that incorporates co-simulation tools will:

- Enable virtual vehicle designs to be functionally tested on computers.
- Optimize vehicle prognostics and performance tools.
- Assess candidate vehicles against critical performance parameters.
- Inform the requirements process by identifying system requirements that are realistic and achievable.
- Inform life-cycle cost (LCC) estimates and significantly reduce the total LCC of the system.
- Save money by reducing design, as well as test and evaluation costs.

- Allow high-fidelity requirements trade-offs with accurate predictions of costs, schedule, and performance (CSP).
- Evaluate potential new technology insertions and their effects on CSP.

5.3.1 PEO LS Future M&S Vision

The Challenge

PEO LS has a need for a universal M&S aggregation tool that is verified, validated and has a high degree of fidelity. This tool will collect and aggregate industry component and platform data for various vehicle systems/platforms, assess the aggregated data through scenario-based simulation, and provide normalized CSP output that will allow leadership to confidently assess the value of a proposed system or upgrade (See Figure 5.3-1).

The development of a universal modeling and simulation aggregation tool will provide:

- Streamlined and standardized approach for assessing CSP of future Ground Combat Vehicles (GCVs) and proposed upgrades/modifications.
- Single integration tool capable of assessing multiple platforms and multiple configurations.
- Plug-and-play capability for upgrade or alternative component comparison, as well as future modernization programs.
- Requirements-based scenarios to assess total LCC and performance for each platform/configuration and upgrade.
- Standardized interfaces for industry

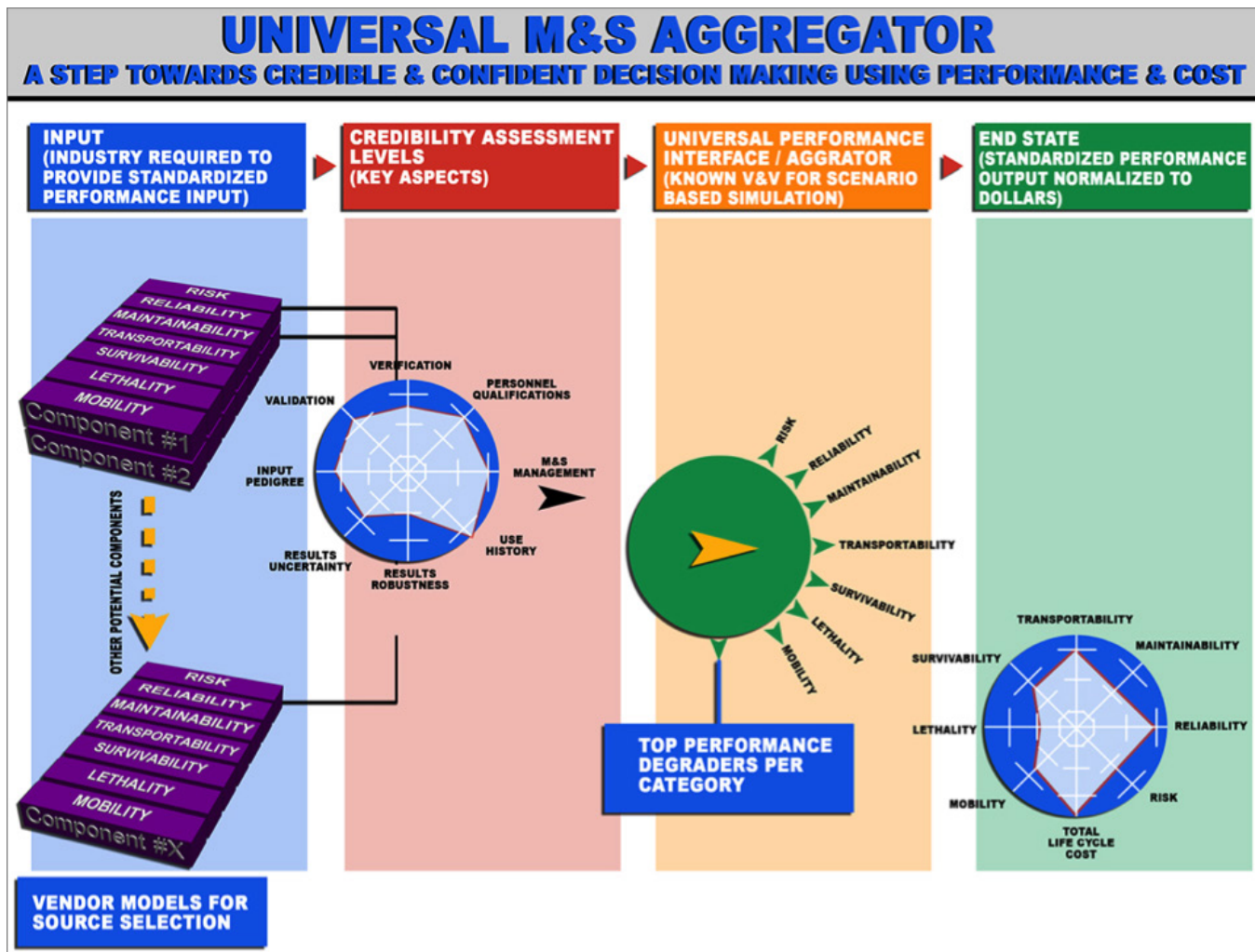


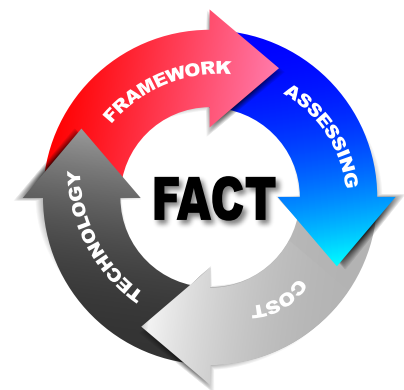
Figure 5.3-1. Universal M&S Aggregator

- to design component models, as well as establishes acceptable credibility assessment levels for key design aspects.
- Decision-making tools for acquisition leadership with a known confidence level.
- Reduced total ownership costs, while maximizing limited S&T resources.

5.3.2 Shaping the Future of M&S

Framework Assessing Cost Technology (FACT)

The United States Marine Corps Systems Command (MCSC) sponsored the development of the Framework for Accessing Cost and Technology (FACT) with Georgia Tech Research Institute (GTRI) to enable investigators to visualize a system's potential costs alongside the systems performance, reliability and other factors deemed important. FACT is a modeling



and simulation framework, enabling real-time collaboration in a web environment, primarily geared towards conducting real-time trade space analysis for complex systems-of-systems. FACT uses Systems Modeling Language (SysML) to define complex systems. SysML expands upon the Unified Modeling Language (UML) and goes beyond software-centric design to include hardware components. The specification provides a formal means to describe a system, most notably the decomposition and organization of the system components as well as the parametric relationships between value properties distributed throughout the systems.

5.3.3 Ongoing M&S Efforts

Human Body Model

Current Anthropomorphic Test Dummies (ATDs) used to predict human injury risk in live-fire blast testing have several limitations due to a lack of biofidelity and limited injury assessment capability. The ATD is composed of metals, rubbers, and plastics, and the majority of injury metrics associated with the ATD were developed under automotive crash loading scenarios.

Development of a human body model is underway; leveraging the recent advances in high-fidelity computational physics-based M&S of explosive events against armored vehicles. This major advancement in the ability to accurately predict human injury risk will enable vehicle designers and evaluators to predict risk of injuries across the severity spectrum experienced in the real world, supplement ATD results with prediction of injuries beyond fracture, expand injury risk assessments beyond the 50th percentile, support theater event reconstruction, and deliver injury causation determination. Beyond the scope of the PEO LS focus on injury prediction in Improvised Explosive Device (IED) events, this model could be used in ballistic protection, blast overpressure, burn injuries, and non-lethal munitions.

Post IED Damage Small Business Innovative Research (SBIR)

Two companies are currently in Phase II of SBIR contracts to develop the capability to systematically gather and store Post IED damage data from the vehicle and scene and process this data into a format that allows the vehicle PMs to assess the risk of repair vs redeployment.

Survive Engineering Company is developing an integrated, low-cost, ruggedized, and portable tablet-based 3D capture tool kit to guide and facilitate the assessment of battle damage to combat vehicle platforms. The plans for the tool includes:

- Development and integration of ruggedized, low-cost indoor/outdoor 3D scanning technology.
- Procedural forms and checklists.
- Photo and video documentation.
- Expandable framework to incorporate other Non-Destructive Inspections (NDI) technologies.

Corvid Technologies is developing Battle Damage Assessment Visualizer (BDAV) software which is run on ultra-portable devices and allows quick time access to a database incorporating hundreds of IED and multi IED-event scenarios. By comparing the damage produced by the incident to a database of simulated vehicle damage, the software determines the closest match and calculates the risk of redeploying vs repairing the vehicle structure. The tool will also support event-reconstruction, identifying the most likely threat scenario that led to the damage. Additionally, as an alternative to visual-only inspection, BDAV provides a more data driven, consistent way to determine vehicle repair levels required, lowering risk to the warfighter while simultaneously reducing unnecessary vehicle downtime. BDAV software relies on robust surface

capture and data storage capability being developed under this same SBIR topic.

Joint Light Tactical Vehicle (JLTV) Blast M&S

The objective of this effort is to develop and execute a physics-based model that is able to account for both soil/structure interaction and gross vehicle response. Corvid Technologies has prepared high-fidelity models for the Marine Corps JLTV Program Office. The Under Body Blast (UBB) M&S efforts will:

- Provide Joint Project Office (JPO) insight into force protection levels (initially from a structural standpoint and evolving to a crew-response standpoint).
- Support engineering design analyses and modifications.
- Provide supplemental information to support key performance parameter analyses. The JPO also plans to use M&S for future evaluations of vehicle design modifications and Engineering Change Proposals (ECPs).

Mitigation of Blast Injuries

The objective of the JLTV Blast Modeling and Simulation (M&S) effort is to develop and execute a physics-based model that can account for both soil/structure interaction and gross vehicle response. Corvid Technologies is developing high-fidelity models for the JLTV programs. The underbody blast M&S efforts will: 1) provide the Joint Project Office (JPO) insight into force protection levels (initially from a structural standpoint and evolving to a crew response standpoint); 2) support engineering design analyses and modifications; and 3) provide supplemental information to support key performance parameter analyses. The JPO also plans to use M&S for future evaluations of vehicle design modifications and engineering change proposals. Funding and timeline information can be found in the M&S section.

Additional M&S projects supporting PEO LS include:

- **Material Characterization of Energy Absorbers (EA)** focuses on material for blast modeling, which is being tested to determine models used to define EA component response. Components to be modeled include seat EAs, cushions and blast mats.

Potential Solutions

Tank Automotive Research, Development and Engineering Center (TARDEC) Efforts

Light Weight Systems & Technology (LWS&T)

This effort will develop a weight informed vehicle design optimization process / architecture for the Army. LWS&T will utilize, develop, and evaluate tools, advanced materials, manufacturing, and assembly technologies to optimize component/sub-system/system weight while maintaining or improving performance. Finally, it will demonstrate best practices in a cost-conscious system design to reduce ground vehicle weight.

Vehicle Electronics and Architecture (VEA) Mobile Demonstrator

The purpose of the project is to mature the open data and power architecture as well as the system designs to TRL 6 that were implemented as part of the VEA Research SIL at TRL 5 by integrating those subsystems onto a combat vehicle platform. This effort will also validate the power and data capabilities required for the future infantry or combat vehicle modernization efforts while increasing vehicle performance & decreasing SWAP over current implementations. Finally, it will build the TARDEC bench on in-house vehicle integration of these systems.

Virtual Proving Ground

The purpose is to develop a comprehensive and integrated Autonomy M&S toolkit strategy, positioning TARDEC to lead the push for more unified / interoperable M&S capabilities.

This project will also engage with on-going M&S tool development efforts (e.g. Autonomy in Operational Energy (AiOE), TARDEC Virtual Experimentation Capability (TVEC), etc.), identify the best-of-breed M&S tools available, and perform a gap analysis to identify areas for future tool enhancement. Other efforts include:

- Develop and extend M&S tools to address shortcomings identified in the gap analysis. (e.g. integrate best-of-breed tools together, expand functionality/robustness, etc.).
- Manage the integration of existing/future M&S tools into the toolkit to reduce duplication of effort and maximize the value of M&S outputs.

Warrior Injury Assessment Manikin (WIAMan)

The purpose of this effort is to establish the feasibility of the WIAMan injury assessment concept and advance to prototype fabrication.

M&S

